

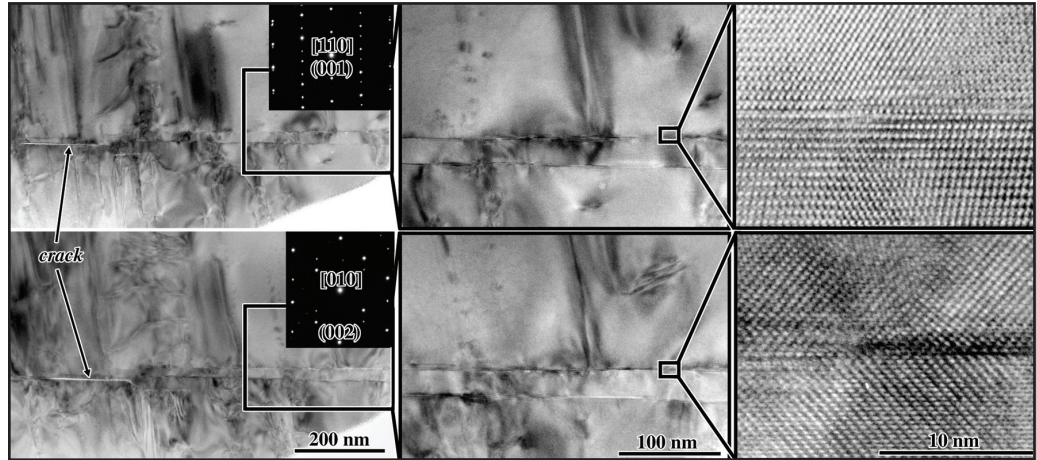


# Air Force Research Laboratory | AFRL

*Science and Technology for Tomorrow's Air and Space Force*

## Success Story

### MATERIALS RESEARCH IN MONAZITE DEFORMATION TWINNING BENEFITS SCIENCE AND DEFENSE



Materials and Manufacturing Directorate scientists have made significant advancements in understanding a phenomenon called deformation twinning, a major materials deformation mode particularly occurring at low temperatures and high strain rates. Working with industry, the researchers have succeeded in identifying five deformation twin modes in the mineral monazite, a complex mineral with low symmetry. The knowledge and insights gained through these efforts will advance technologies critical to tomorrow's defense needs, enhance the performance of important commercial products, and promote the creation of new technologies and products within the private sector.



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## Accomplishment

Scientists at the directorate's Metals, Ceramics, and Nondestructive Evaluation Division, working with Rockwell Scientific Company, Thousand Oaks, California, deformed polycrystalline monazite at room temperature using a spherical indenter. They have been able to explain the existence of these modes with fundamental principles that should be useful for prediction in systems that are more complex. These studies help provide scientists with the knowledge required to create better, more advanced tools for analyzing the composition and application potential of minerals and other natural materials valuable to systems developed for national defense. They also aid in the research and development of dynamic new commercial products.

## Background

Twinning, a natural phenomenon in crystal alignment, originates in one of three ways: via growth twinning, transformation twinning, or deformation twinning. Growth twinning occurs as a result of accidents during crystal growth, resulting in a new crystal being added to the face of an existing one. Transformation twinning occurs as a strain accommodation mechanism during phase transformations induced by pressure or temperature. Deformation twinning occurs when lattice points in one crystal are sheared to resemble lattice points in another crystal, creating symmetry. Deformation twinning is a common plasticity mechanism in body-centered cubic metals. The process is less understood in more complex materials, but is typically the dominant deformation mechanism at low temperatures and high strain rates, which makes it of particular interest for impact-resistant materials.

Naturally occurring monazite is typically a reddish-brown mineral whose name derives from the Greek word monazit, meaning "to be alone," because it was considered extremely rare when first discovered. It contains cerium, lanthanum, and neodymium, known as "rare earth" elements, and the radioactive element thorium. Monazite's rare earth elements are used in high-performance magnets, as pigment in ceramics, and in robot motors, fiber optics, X-ray screens, energy-efficient lanthanum lamps, and color television tubes.

Monazite has received attention for its use in structural ceramics that rely on the mineral's unusual combination of properties like high temperature stability, compatibility with common structural oxide ceramics, relatively low hardness, and weak bonding with other oxide ceramics. The low hardness and weak bonding are especially important for machined ceramics, where they enable material removal, and for fiber reinforced composites, where they allow crack deflection and fiber pullout, without the problem of oxidation experienced by more commonly used interfaces.

## Additional information

To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (04-ML-28)